Texas Instruments

TPIC2801

Intelligent-Power Device with Serial Input and Eight 1-A/30-V Low-Side Power Switches

Application Report

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Linear Products

TPIC2801 Intelligent-Power Device with Serial Input and Eight 1-A/30-V Low-Side Power Switches

TEXAS INSTRUMENTS

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Introduction

The TPIC2801 is a monolithic, intelligent-power device that contains eight 1-A/30-V low-side power switches packaged in a 15-pin Single-In-Line Package (SIP). The eight switches are controlled from a single input, SI (Serial Input), by an 8-bit serial word. Diagnostics are provided through the output, SO (Serial Output), which permits a comparison of the serial input data with the serial output data. Data no-match indicates a fault condition.

The independent overvoltage and overcurrent protection provided to all eight switches allows the TPIC2801 to switch in harsh electrical and thermal environments. Also, all of the eight switches are equipped with an internal 35-V collector-to-base zener clamp that greatly enhances their capability to switch unclamped inductive loads. Since the clamp allows the power switch to be forward biased instead of avalanched during inductive-load turn-off, a 40-mJ maximum unclamped inductive-energy capability can be achieved.

In addition to the direct drive of peripheral loads such as lamps, solenoids, relays, and motors, the TPIC2801 is also recommended for driving power bipolar and power MOSFET transistors. A power bipolar transistor, when switching amperes of load current, requires several hundred milliamperes of base current for saturated switching. A power MOSFET transistor, when switching at high speed, also requires several hundred milliamperes of peak gate drive current. The TPIC2801 can easily meet all of these requirements.

Functional Description

The TPIC2801 contains an 8-bit serial-in, parallel-out shift register that feeds an 8-bit parallel latch, which independently controls each of the eight Y-output drivers, see Figure 1.

Data is entered into the device serially via SI and goes directly into the lowest bit (0) of the shift register. Using proper timing signals, the input data is passed to the corresponding output latch and output driver. A logic-high bit at SI turns the corresponding output driver (Yn) off. A logic-low bit at SI turns the corresponding output driver on. Serial data is transferred into SI on the high-to-low transition of SCLK (Serial Clock) input in 8-bit bytes with data for Y7 output (MSB) first and data for the Y0 output (LSB) last. Both SI and SCLK are active when $\overline{\text{SIOE}}$ (Serial Input-Output Enable) is low and disabled when $\overline{\text{SIOE}}$ is high.

Each driver output is monitored by a voltage comparator that compares the Y-output voltage level with an internal out-of-saturation threshold voltage reference level. The logic state of the comparator's output is dependent upon whether the Y-output is greater or smaller than the reference voltage level. An activated driver output will be unlatched and turned off when the output voltage exceeds the out-of-saturation threshold voltage level except when the internal unlatch enable is low and disabled. The high-to-low transition of $\overline{\text{SIOE}}$ transfers the logic state of the comparator's output to the shift register.

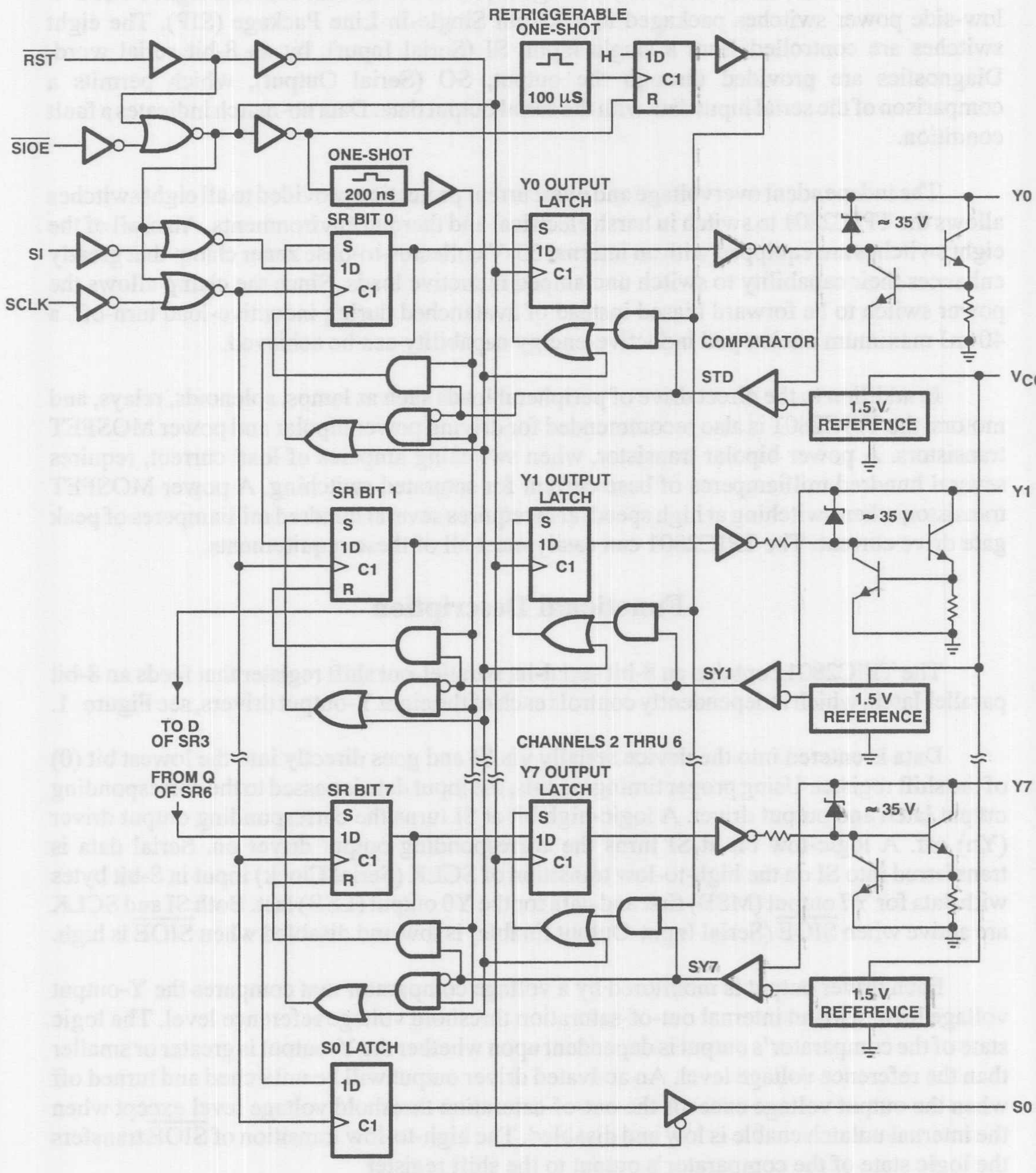
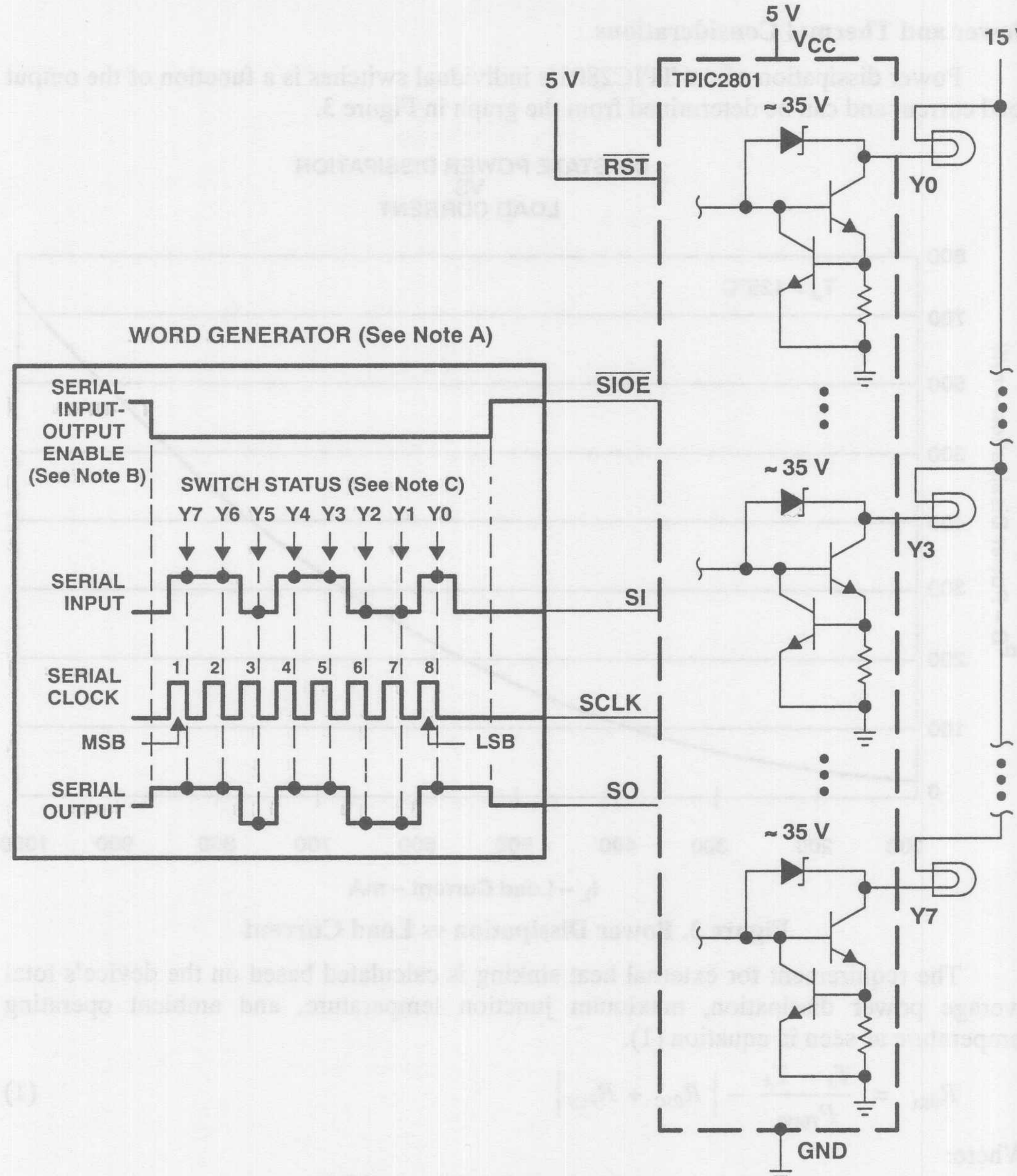


Figure 1. TPIC2801 Functional Block Diagram

Figure 2 illustrates a TPIC2801 switching operation. The figure contains a timing diagram that shows a controller programmed for latching on TPIC2801 output switches Y5, Y2, and Y1 (Serial Input Data Word 11011001).



NOTES: A. Serial Input Word = 11011001.

B. All outputs latched during the positive-going $\overline{\text{SIOE}}$ edge; outputs Y1, Y2, and Y5 latched on, other outputs latched off.

C. A Serial Input high during the negative-going SCLK edge turns the corresponding output off; a Serial Input low turns the corresponding output on.

Figure 2. TPIC2801 Switching Operation

Application Design Considerations

Power and Thermal Considerations

Power dissipation of the TPIC2801's individual switches is a function of the output load current and can be determined from the graph in Figure 3.

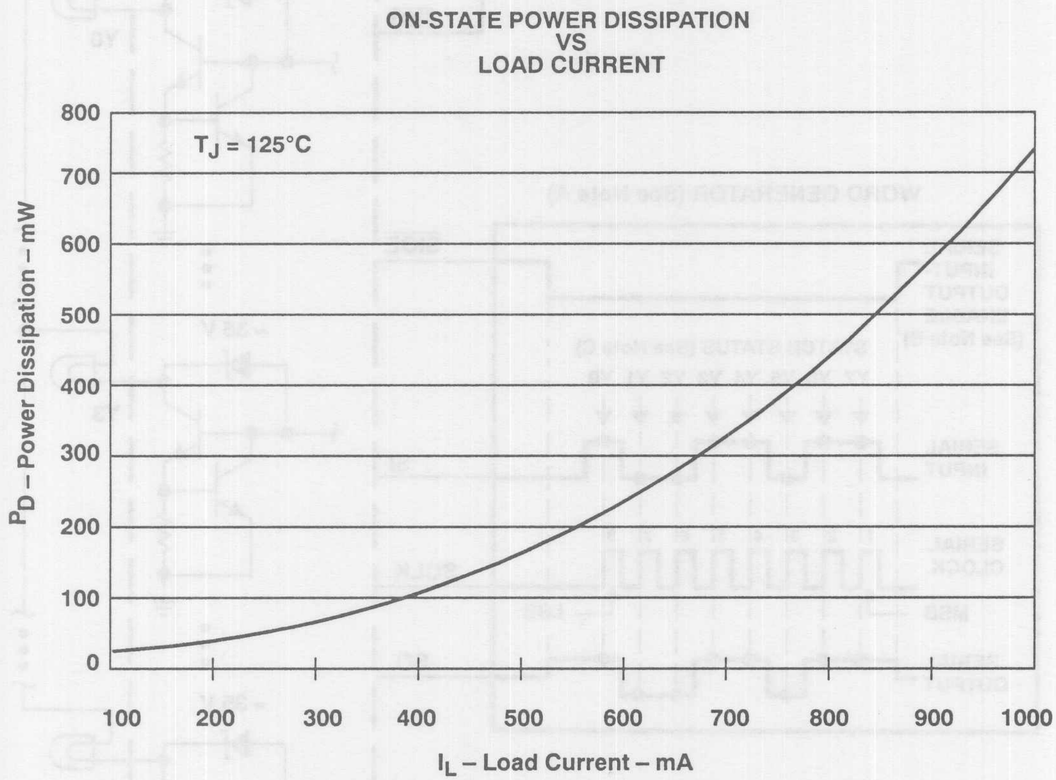


Figure 3. Power Dissipation vs Load Current

The requirement for external heat sinking is calculated based on the device's total average power dissipation, maximum junction temperature, and ambient operating temperature as seen in equation (1).

$$R_{\theta SA} = \frac{T_J - T_A}{P_{T(AV)}} - \left| R_{\theta JC} + R_{\theta CS} \right| \qquad (1)$$

Where:

$R_{\theta SA}$ = heat sink-to-ambient thermal resistance, °C/W
$R_{\theta JC}$ = device junction-to-case thermal resistance
= 3.0°C/W
$R_{\theta CS}$ = case-to-heat sink thermal resistance, °C/W
= 0.5°C/W typical with thermal joint compound
$P_{T(AV)}$ = total average power dissipation, W
T_J = junction operating temperature, °C
T_A = operating ambient temperature, °C

If the $R_{\theta SA}$ calculated is less than 35.0°C/W, an external heat sink is required. The size heat sink necessary to achieve the required $R_{\theta SA}$ can be determined from Figure 4 or from a heat sink catalog.

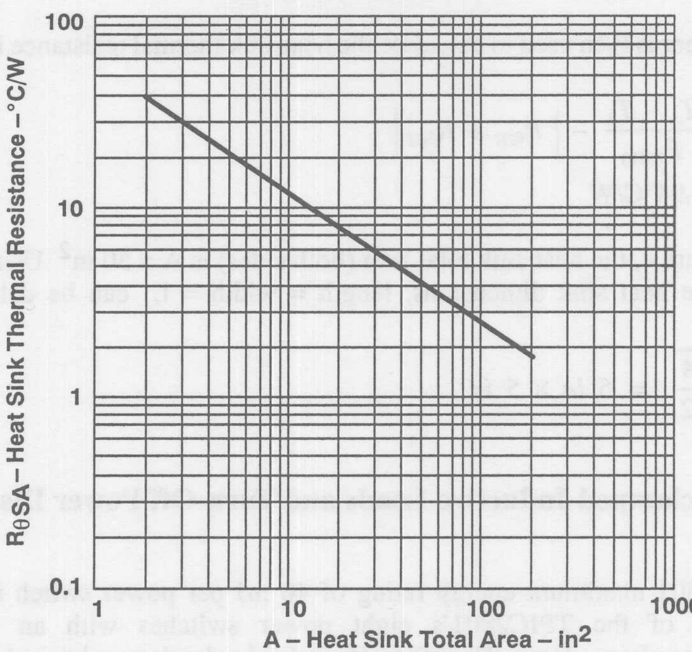


Figure 4. Typical Heat Sink Thermal Resistance vs Heat Sink Total Area

Example 1: Determining Heat Sink Thermal Resistance and Size

Operating Conditions

$T_A = 100°C$
$T_J = 125°C$
TPIC2801 Quiescent Current: $I_{CC} = 0.25$ A
TPIC2801 Supply Voltage: $V_{CC} = 5$ V
Output Switches Y0 @ Y4: $I_L = .5$ A each, duty cycle = 0.5
Output Switches Y1 @ Y5: $I_L = 0.7$ A each, duty cycle = 0.8
Output Switches Y2 @ Y6: $I_L = 0.8$ A each, duty cycle = 1
Output Switch Y3: $I_L = 0.5$ A, duty cycle = 1
Output Switch Y7: $I_L = 0.9$ A, duty cycle = 1

The equations from Figure 3 are as follows:

P(Y0@ Y4) = 0.15 W × 0.5 × 2 = 0.15 W
P(Y1 @ Y5) = 0.3 W × 0.8 × 2 = 0.48 W
P(Y2 @Y6) = 0.4 W × 1 × 2 = 0.8 W
P(Y3) = 0.15 W × 1 × 1 = 0.15 W
P(Y7) = 0.53 W × 1 × 1 = 0.53 W

From TPIC2801 Specification: P(QUIES) = 0.25 A × 5 V = 1.25 W

Next, the total average power dissipation is calculated in equation (2).

$$P_{T(AV)} = P[(Y0 @ Y4) + (Y1 @Y5) + (Y2 @ Y6) + Y3 + Y7] + P(QUIES) \qquad (2)$$
$$= 3.36\ W$$

This number is then used to calculate the heat sink thermal resistance in equation (1).

$$R_{\theta SA} = \frac{T_J - T_A}{P_{T(AV)}} - \left| R_{\theta JC} + R_{\theta CS} \right| \qquad (1)$$
$$= 3.94°C/W$$

From Figure 4, the heat sink total area (both sides) is A = 50 in^2 .Using this number for the area, the heat sink dimensions, length = width = l, can be determined using equation (3).

$$l = \sqrt{\frac{A}{2}} = 5\ in \times 5\ in \qquad (3)$$

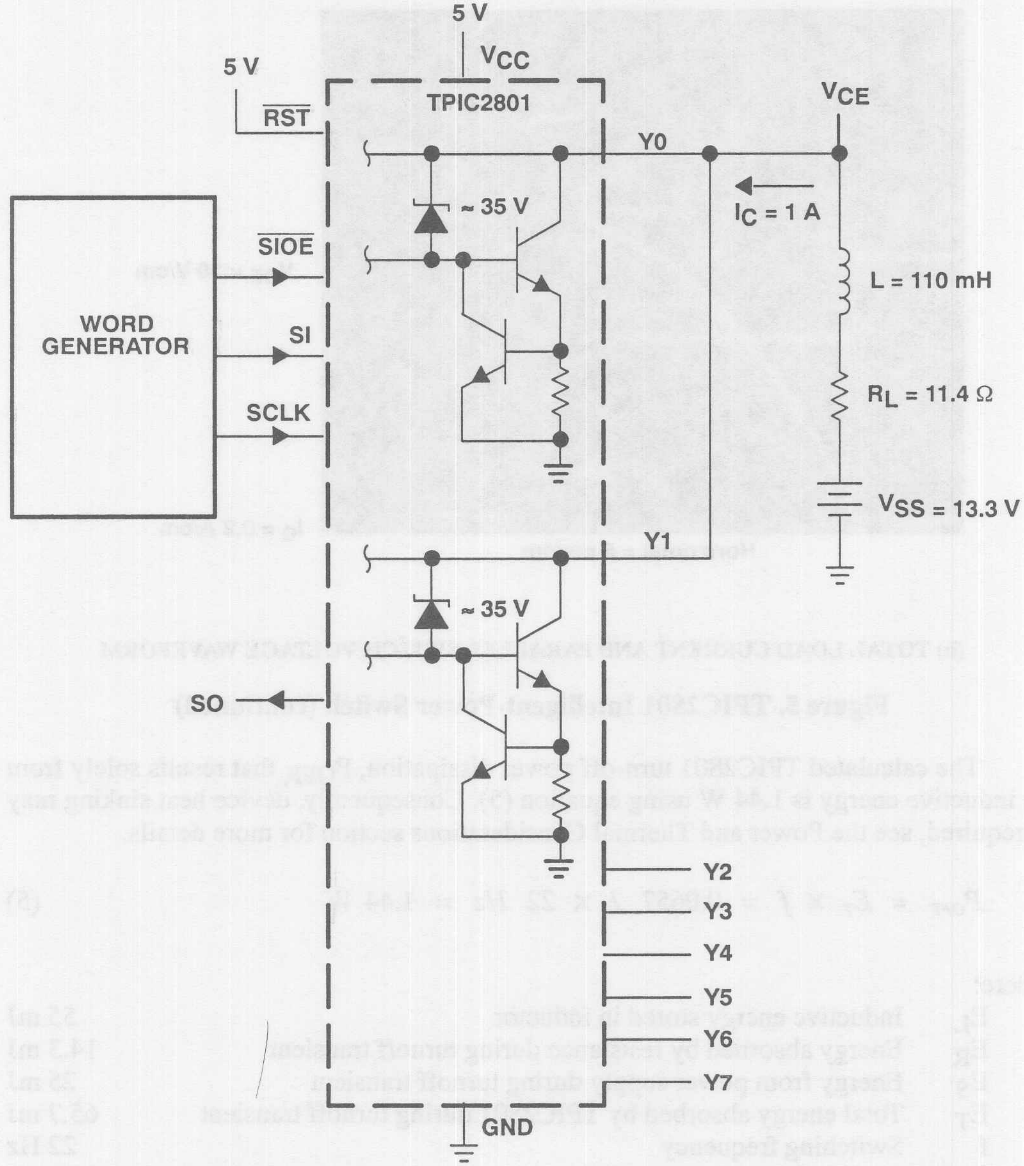
Switching Unclamped-Inductive Loads and Turn-Off Power Dissipation, P_{OFF}

A TPIC2801 maximum energy rating of 40 mJ per power switch is achieved by providing each of the TPIC2801's eight power switches with an internal 35-V collector-to-base voltage clamp. Therefore, for inductive loads equal to or less than 40 mJ, no external voltage clamp is required. The collector-to-base clamp forces energy to be absorbed by the TPIC2801 in the very rugged "Forward-Bias" mode vs the unclamped, less rugged, "Reverse-Bias" mode. Also, the switches can be operated in parallel to extend the capability of an individual switch.

Figure 5(a) shows two of the TPIC2801 power switches connected in parallel switching a 110-mH/11.4-Ω/1-A load at a 50% duty cycle, 22-Hz repetition rate from a 13.3-V supply.

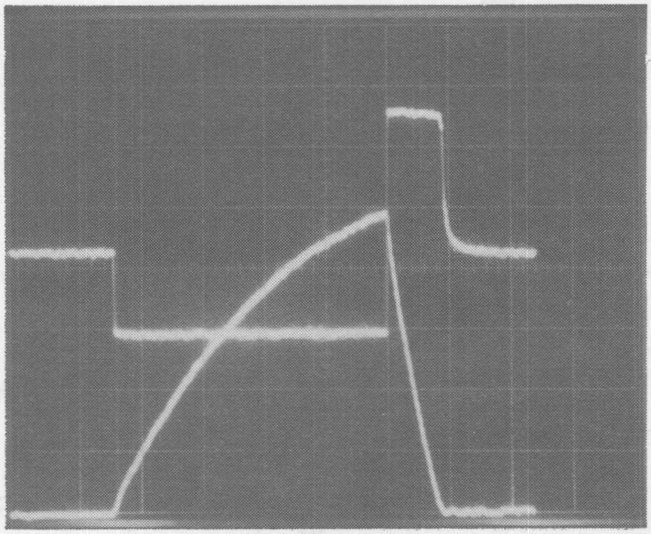
Figure 5(b) shows the total load current and parallel switch voltage waveform while the TPIC2801 is absorbing a calculated total inductive energy of 65.7 mJ (32.8 mJ per switch) using equation (4).

$$E_T = E_L + E_S - E_R = \frac{3 \times L_H \times {I_P}^2 \times V_{OK}}{6 \times V_{OK} - 6 \times V_{SS} + 4 \times R_L \times I_P} = 65.7\ mJ \qquad (4)$$



(a)TPIC2801 POWER SWITCHES CONNECTED IN PARALLEL

Figure 5. TPIC2801 Intelligent-Power Switch



(b) TOTAL LOAD CURRENT AND PARALLEL SWITCH VOLTAGE WAVEFORM

Figure 5. TPIC2801 Intelligent-Power Switch (continued)

The calculated TPIC2801 turn-off power dissipation, P_{OFF}, that results solely from the inductive energy is 1.44 W using equation (5). Consequently, device heat sinking may be required, see the Power and Thermal Considerations section for more details.

$$P_{OFF} = E_T \times f = 0.0657\ J \times 22\ Hz = 1.44\ W \tag{5}$$

Where:

E_L	Inductive energy stored in inductor	55 mJ
E_R	Energy absorbed by resistance during turnoff transient	14.3 mJ
E_S	Energy from power supply during turnoff transient	25 mJ
E_T	Total energy absorbed by TPIC2801 during turnoff transient	65.7 mJ
f	Switching frequency	22 Hz
L_H	Load inductance	110 mH
I_P	Peak output load current	1 A
P_{OFF}	Turnoff power dissipation TPIC2801	1.44 W
R_L	Resistance of inductor	11.4 Ω
V_{OK}	Clamp voltage	35 V
V_{SS}	Load supply voltage	13.3 V

Based on "JEDEC Suggested Standard No. 10 for Power Transistors", paragraph 3.2.5, the TPIC2801 under test will absorb a total energy of 65.7 mJ maximum and dissipate a turn-off power of 1.44 W minimum per the test conditions specified above.

Parallel Operation of Output Switches for Extended Current Capability

If all eight output switches are not needed for an application and an output load current greater than 1 A is required, the switches can be connected in parallel for extended current capability. The current sharing capability of the TPIC2801 switches is demonstrated in Figure 6 circuit while operating at T_A = 25°C on a 3.5 x 3.5 inch heat sink. The individual switch currents are listed in Table 1 while the TPIC2801 was conducting a total current of: 1) 4 A with 8 switches on, 2) 3 A with 6 switches on, 3) 2 A with 4 switches on, and 4) 1 A with 2 switches on.

Table 1. Typical Load Current Data, Parallel Switch Operation

Tab Temp (°C)	$I_{(T)}$ (A)	V_{CE} (A)	$I_{(0)}$ (A)	$I_{(1)}$ (A)	$I_{(2)}$ (A)	$I_{(3)}$ (A)	$I_{(4)}$ (A)	$I_{(5)}$ (A)	$I_{(6)}$ (A)	$I_{(7)}$ (A)
40	4	0.53	0.6	0.52	0.45	0.43	0.45	0.46	0.51	0.58
35	3	0.47	0.58	off	0.45	0.43	off	0.46	0.51	0.57
31	2	0.41	off	0.51	off	0.46	off	0.47	off	0.56
28	1	0.39	off	off	off	0.5	0.5	off	off	off

Application Design Examples

Operation of Eight Lamps Featuring TPIC2801 Soft-Start Circuit

Figure 7 shows the TPIC2801 circuit switching eight No. 168 automotive lamps from a 15-V source and various waveforms.

Figure 7(a), with the TPIC2801 clock operating at a frequency of 5 kHz, shows the input control waveforms $\overline{\text{SIOE}}$, SCLK, SI (00000000 for all eight outputs on), and the SO output. Figure 7(b) shows the initial lamp in-rush current decrease from a value slightly greater than 1.5 A to a value less than 0.5 A during a period of approximately 120 ms. Figure 7(c) shows the first $\overline{\text{SIOE}}$ pulse that follows the first data word and the lamp current, a 1.5-A/100-µs pulse that is coincident with the rising edge of the $\overline{\text{SIOE}}$ pulse.

The rising edge of the $\overline{\text{SIOE}}$ pulse following the data word is when shift register data is latched into the parallel latch and the output switches are activated by the new data. However, to allow the part to overcome high in-rush current, such as the lamp cold filament current, and internal 100-µs delay timer is started at the $\overline{\text{SIOE}}$ pulse rising edge during which time the switch overvoltage fault shutdown circuit is inhibited. During this 100-µs interval the switch is protected by an internal current limiter, which is set to regulate the current to approximately 1.5 A to 1.8 A. Once the 100-µs delay period has elapsed, the output voltages are sensed by the comparators and any output switch with voltage higher than 1.5 V is latched off. It is important to note that these current-limited, 100-µs, soft-start bursts of power not only protect the TPIC2801, but also protect the lamp filament from an otherwise filament degrading, high in-rush current.

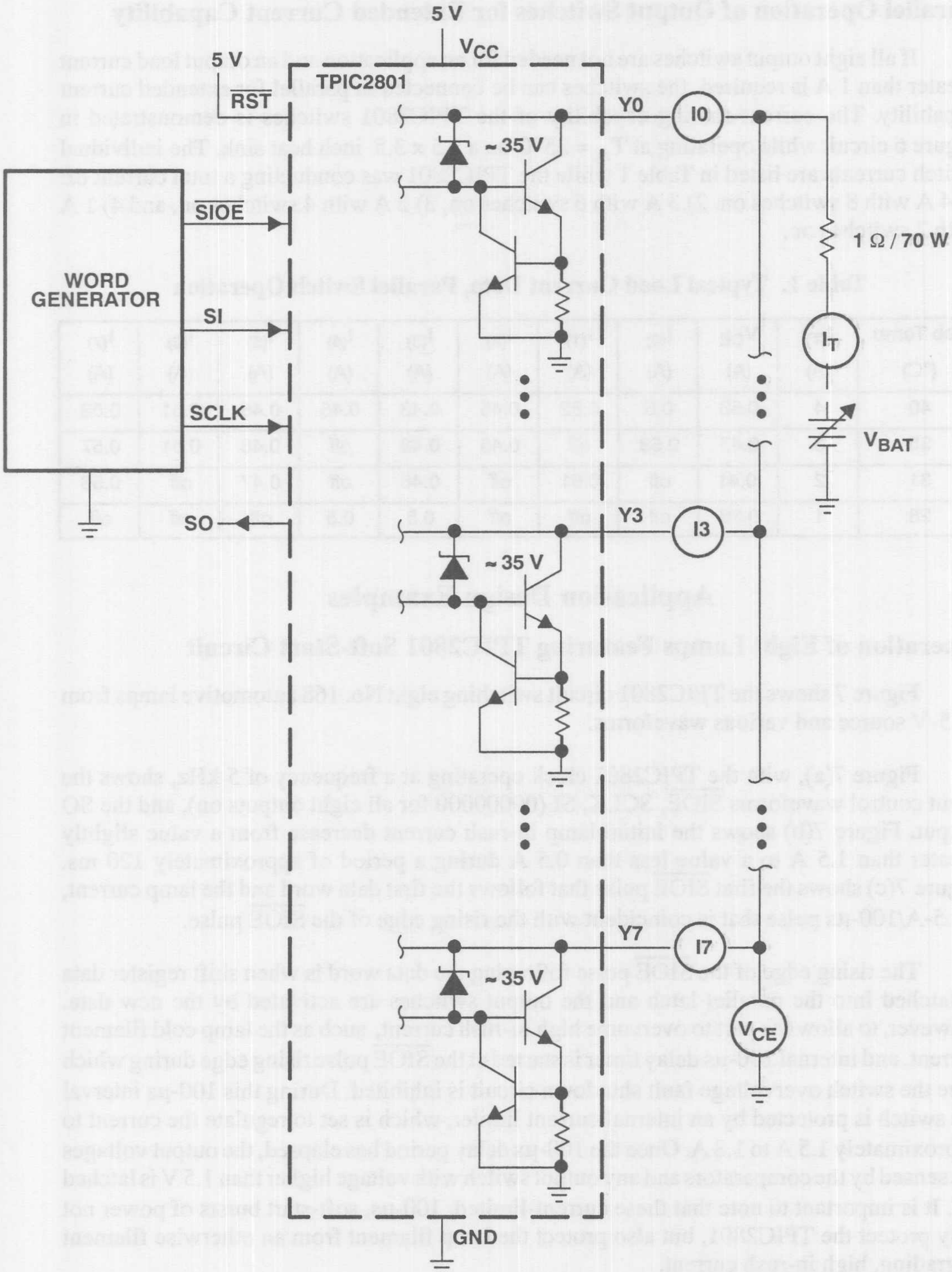
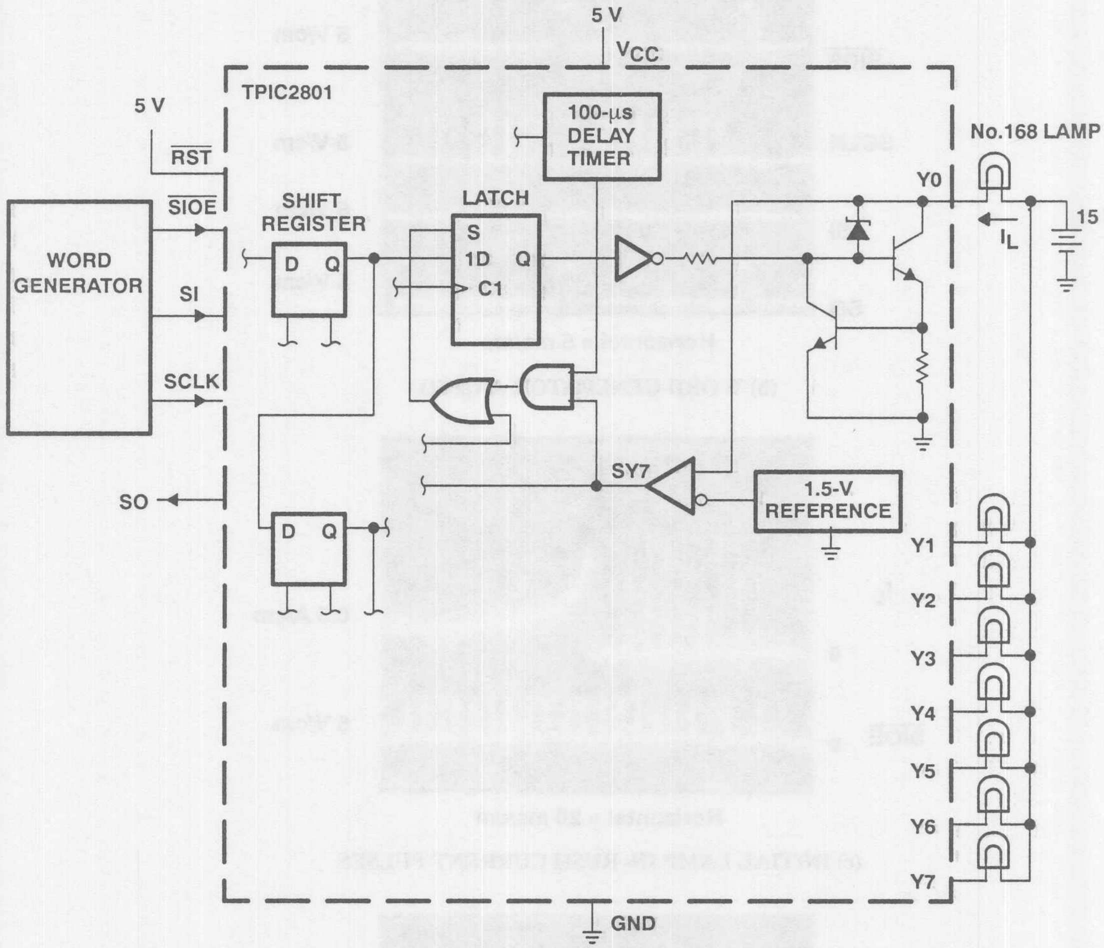
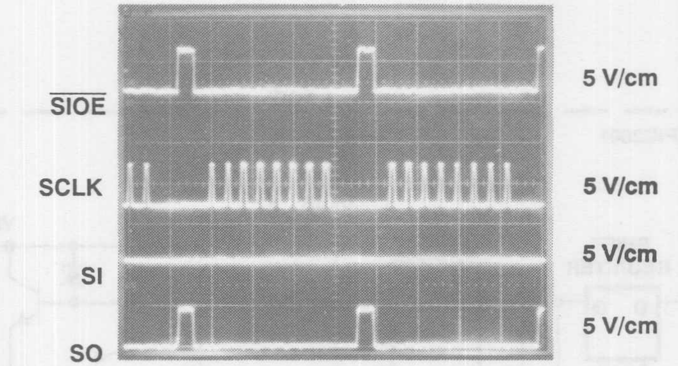


Figure 6. Parallel Operation of Output Switches for Extended Current Capability



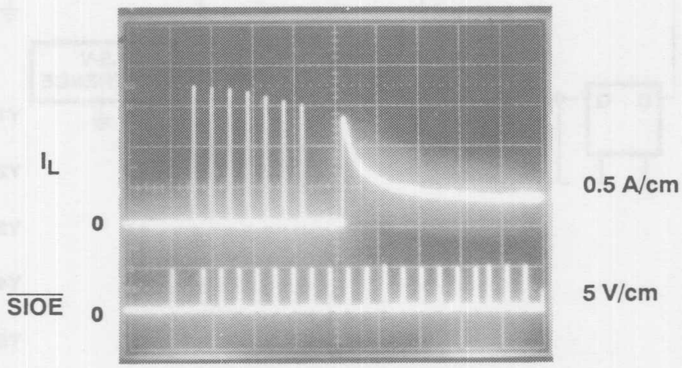
(a) TPIC2801 AUTOMOTIVE LAMP SWITCHING TEST CIRCUIT

Figure 7. TPIC2801 Simultaneous Switching of Eight Automotive Lamps



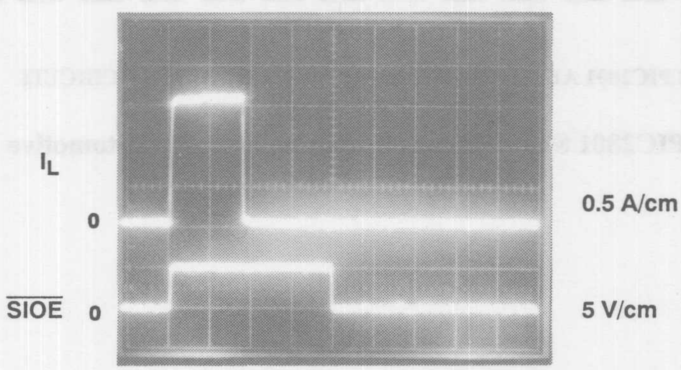
Horizontal = 5 ms/cm

(b) WORD GENERATOR AND SO



Horizontal = 20 ms/cm

(c) INITIAL LAMP IN–RUSH CURRENT PULSES



Horizontal = 50 ms/cm

(c) INITIAL $\overline{\text{SIOE}}$ AND LAMP CURRENT PULSE

Figure 7. TPIC2801 Simultaneous Switching of Eight Automotive Lamps (Continued)

Direct Drive of Automobile High-Impedance Fuel Injectors

Figure 8 shows the test circuit and oscilloscope waveforms of the TPIC2801 switching four automobile high-impedance fuel injectors (R =13.3 Ω and L = 9 mH) from a 15-V source. The TPIC2801 provides 1-A rated current to each injector by the parallel operation of output switches Y0 || Y4, Y1 || Y5, Y2 ||Y6, and Y3 || Y7.

The calculated total inductive energy absorbed by each parallel switch combination is 5.3 mJ from equation (4), which is considerably less than the 40 mJ per switch TPIC2801 rating. For more information see the Switching Unclamped Inductive Loads section.

$$E_T = E_L + E_S - E_R = \frac{3 \times L_H \times I_P{}^2 \times V_{OK}}{6 \times V_{OK} - 6 \times V_{SS} + 4 \times R_L \times I_P} = 5.3\ mJ \qquad (4)$$

The calculated turn-off power dissipation P_{OFF} is 0.47 W as seen is equation (5).

$$P_{OFF} = E_T \times f = 0.0053\ J \times 22\ Hz \times 4\ loads = 0.47\ W \qquad (5)$$

Where:

E_L	Inductive energy stored in inductor	4.5 mJ
E_R	Energy absorbed by resistance during turnoff transient	1.1 mJ
E_S	Energy from power supply during turnoff transient	1.9 mJ
E_T	Total energy absorbed by TPIC2801 during turnoff transient	5.3 mJ
f	Switching frequency	22 Hz
L_H	Load inductance	9 mH
I_P	Peak output load current	1 A
P_{OFF}	Turnoff power dissipation on TPIC2801 (from L_H energy)	0.47 W
R_L	Resistance of inductor	13.3 Ω
V_{OK}	Clamp voltage	37 V
V_{SS}	Load supply voltage	15 V

Unipolar Stepper Motor Drive

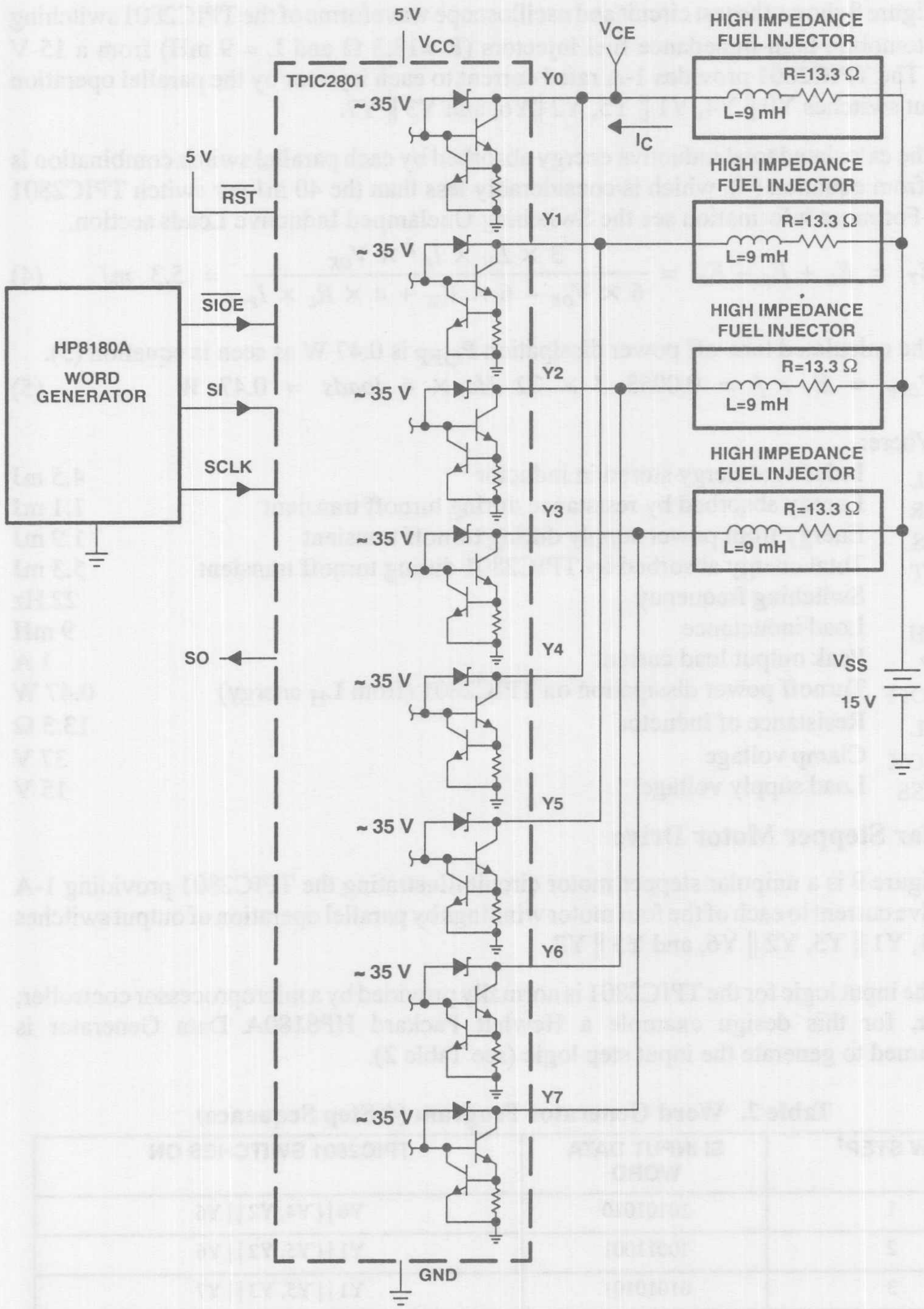
Figure 9 is a unipolar stepper motor circuit illustrating the TPIC2801 providing 1-A rated drive current to each of the four motor windings by parallel operation of output switches Y0 || Y4, Y1 || Y5, Y2 || Y6, and Y3 || Y7.

The input logic for the TPIC2801 is normally provided by a microprocessor controller; however, for this design example a Hewlett Packard HP8180A Data Generator is programmed to generate the input step logic (see Table 2).

Table 2. Word Generator Program (4-Step Sequence)

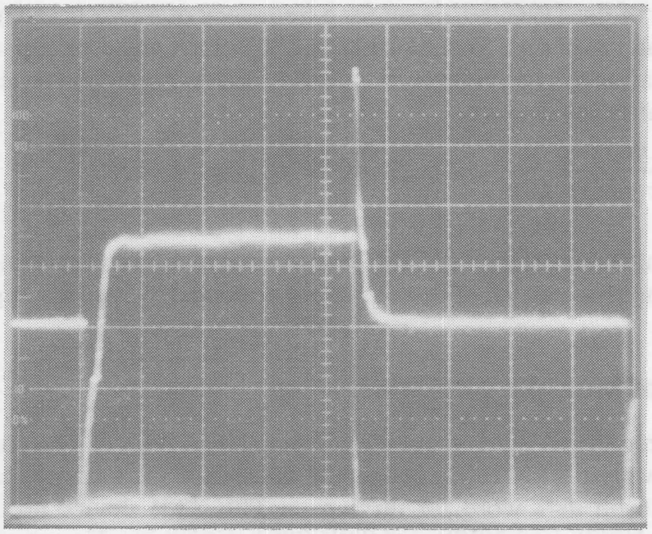
CW STEP†	SI INPUT DATA WORD	TPIC2801 SWITCHES ON
1	10101010	Y0 || Y4, Y2 || Y6
2	10011001	Y1 || Y5, Y2 || Y6
3	01010101	Y1 || Y5, Y3 || Y7
4	01100110	Y0 || Y4, Y3 || Y7
1	10101010	Y0 || Y4, Y2 || Y6

† For CCW rotation, read step sequence up from bottom.



(a) TPIC2801 AUTOMOTIVE FUEL INJECTOR SWITCHING TEST CIRCUIT

Figure 8. TPIC2801 Switching Multiple High-Impedance Fuel Injectors



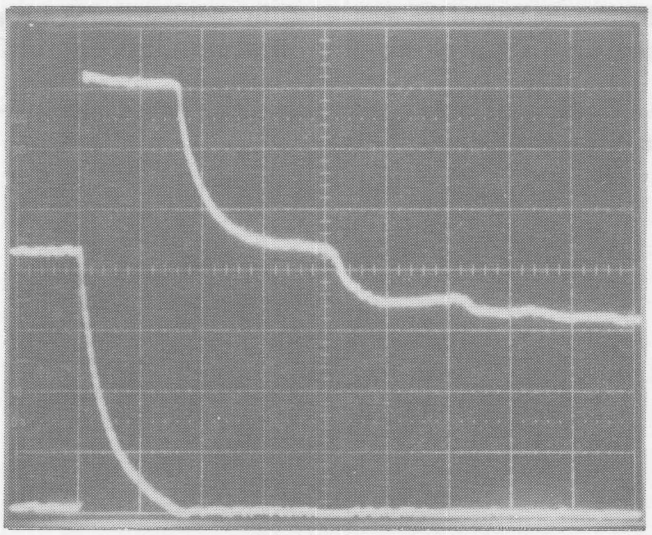
V_{CE} = 5 V/cm

I_C = 0.2 A/cm

0

Horizontal = 5 ms/cm

(b) OUTPUT VOLTAGE AND CURRENT WAVEFORMS



V_{CE} = 5 V/cm

0

I_C = 0.2 A/cm

Horizontal = 0.2 ms/cm

(c) EXPANDED VIEW OUTPUT VOLTAGE AND CURRENT WAVEFORMS

Figure 8. TPIC2801 Switching Multiple High-Impedance Fuel Injectors (Continued)

The system clock of the TPIC2801 is set for a frequency of 4 kHz based on time per motor step of 2.5 ms and based on a total of 10 TPIC2801 clock pulses required per each motor step as seen in equation (6); i.e., eight clock pulses for the data word plus one additional clock pulse before and after the data word.

$$t_{CLK} = \frac{2.5 \ \ ms/step}{10 \ \ clock \ \ pulses \ \ step} = 0.25 \ \ ms \ or \ f_{CLK} = 4 \ \ kHz \qquad (6)$$

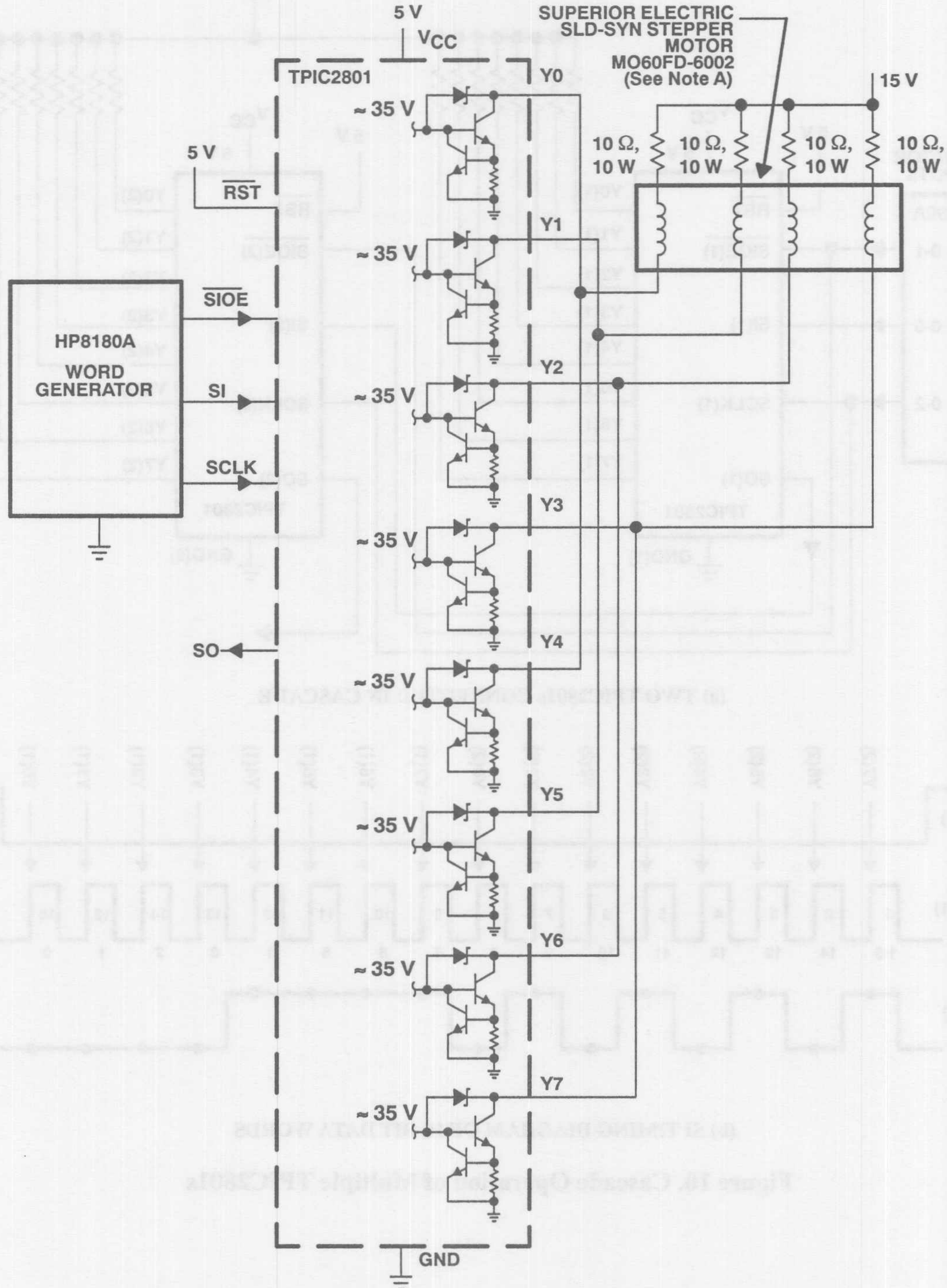
One very important feature of the TPIC2801 as a stepper motor driver is that it requires no external voltage clamps because all of its outputs are protected by internal, high-energy, 35-V voltage clamps.

Cascade Operation of Multiple TPIC2801s

By shifting data into the SI pin and out the SO pin, TPIC2801s can be connected in cascade. Figure 10 shows two TPIC2801s connected in cascade including an example SI timing diagram of the16-bit data word for turning on TPIC2801 device no. 2's output switches Y6(2), Y4(2), Y2(2), and Y0(2) and TPIC2801 device no. 1's output switches Y3(1), Y2(1), Y1(1), and Y0(1). Also, Figure 10 is an oscilloscope waveform of device no. 1's operation per the conditions described.

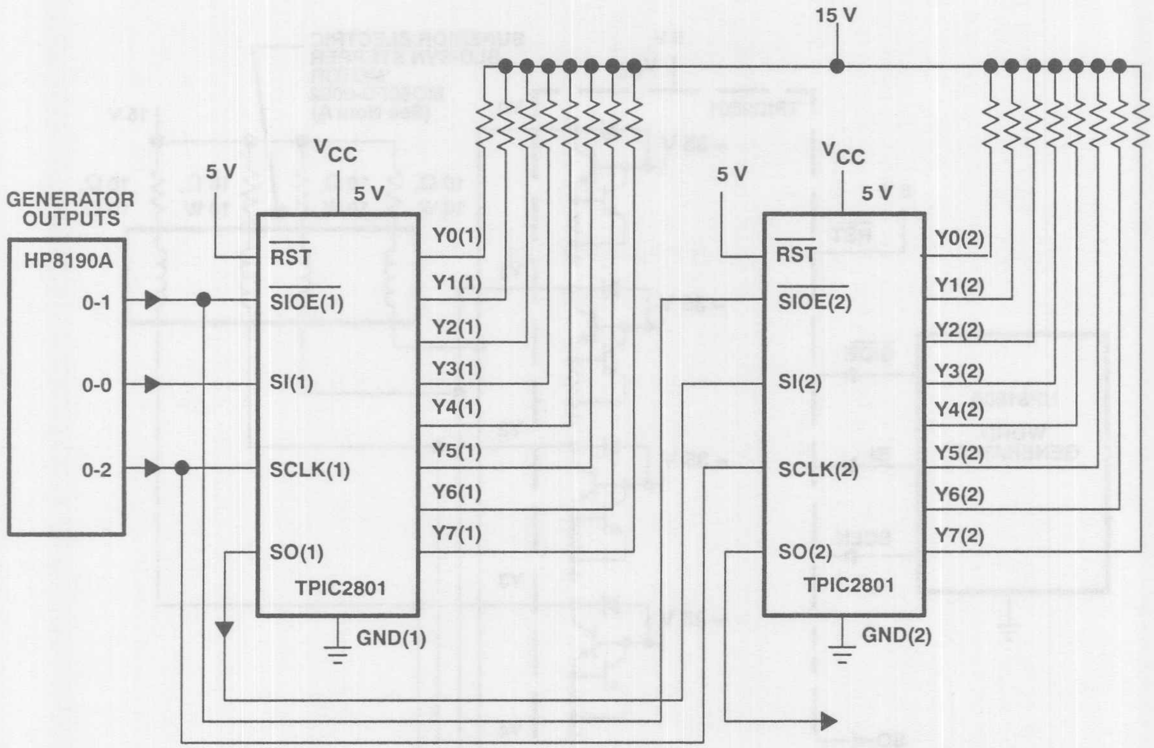
Note that in the $\overline{\text{SIOE}}$ chip enable pin is pulled low at the beginning of the SI 16-bit data word and is pulled high at the end of the data word. In addition, the SCLK pin should be low at both transitions of the $\overline{\text{SIOE}}$ pin to avoid any false clocking of the shift register.

The HP8180A Data Generator Data Page for generating the example 16-bit timing diagram explained above is listed in Table 3.

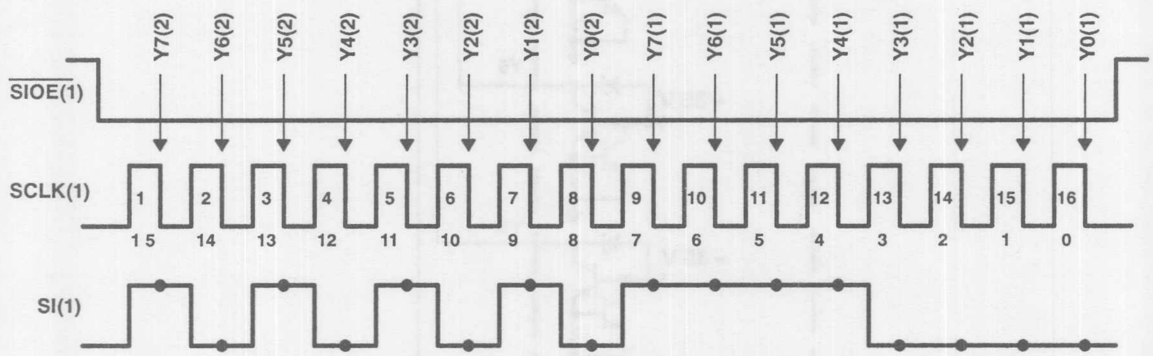


NOTE A: I = 1 A per phase, L = 10 mH per phase, R = 5 Ω per phase, T = 2.5 ms per step.

Figure 9. Unipolar Stepper Motor Drive Circuit

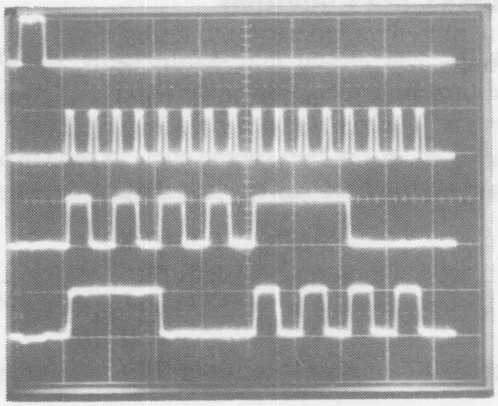


(a) TWO TPIC2801s CONNECTED IN CASCADE



(b) SI TIMING DIAGRAM OF 16-BIT DATA WORDS

Figure 10. Cascade Operation of Multiple TPIC2801s



(c) WAVEFORMS OF FIGURE 10(b) AND NO. 1 OUTPUT SO

Figure 10. Cascade Operation of Multiple TPIC2801s (Continued)

Table 3. HP8180A Data Generator Data

ADDRESS	STR	DATA (for generator outputs)			
		0–3 Out not used	0–2 Out "RZ"† SCLK	0–1 Out "NRZ" $\overline{\text{SIOE}}$	0–0 Out "NRZ" SI
0000	1	x	0	1	0
0001	0	x	0	0	0
0002	0	x	1	0	1
0003	0	x	1	0	0
0004	0	x	1	0	1
0005	0	x	1	0	0
0006	0	x	1	0	1
0007	0	x	1	0	0
0008	0	x	1	0	1
0009	0	x	1	0	0
0010	0	x	1	0	1
0011	0	x	1	0	1
0012	0	x	1	0	1
0013	0	x	1	0	1
0014	0	x	1	0	0
0015	0	x	1	0	0
0016	0	x	1	0	0
0017	0	x	1	0	0
0018	0	x	0	0	0

† The width is equal to 2.5 µs.
NOTE: The frequency is equal to 100 kHz.

Simultaneous Turn-on/Turn-off of Eight Inductors that Simulate Driving Solenoids Under Worse Case Condition

Figure 11 shows the test circuit and oscilloscope waveforms of the TPIC2801 switching eight high-inductance inductors (R = 30 Ω and L = 250 mH) from a 15.5-V source. The TPIC2801 provides 0.5-A current to each inductor while each TPIC2801 output switch absorbs an inductive energy of 36.7 mJ per switch cycle as seen in equation (4), which is safe operating condition based on the TPIC2801's 40-mJ maximum unclamped energy rating.

$$E_T = E_L + E_S - E_R = \frac{3 \times L_H \times I_P{}^2 \times V_{OK}}{6 \times V_{OK} - 6 \times V_{SS} + 4 \times R_L \times I_P} = 36.7 \ mJ \qquad (4)$$

The calculated power dissipation P_{OFF} is 1.58 W as seen in equation (5).

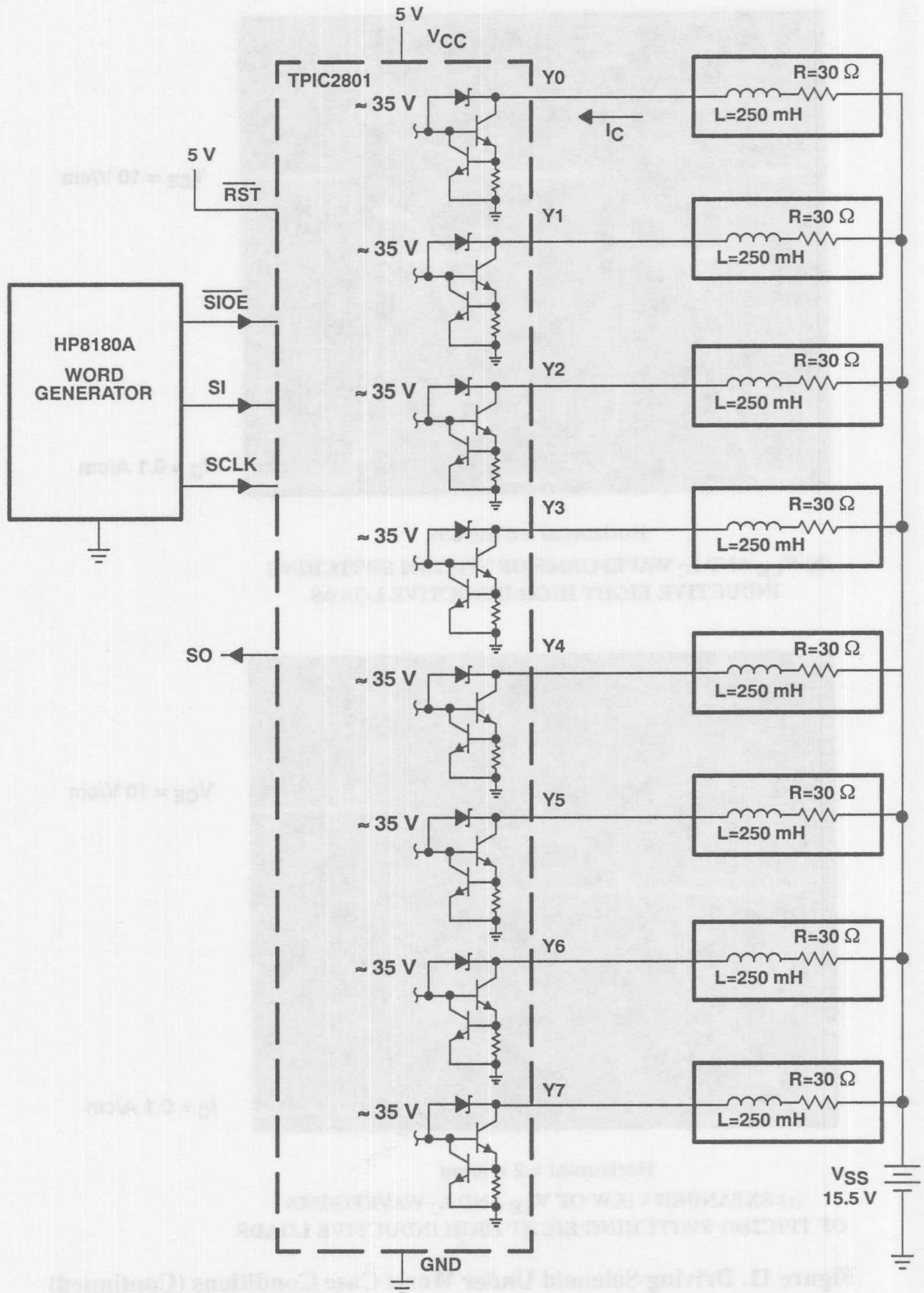
$$P_{OFF} = E_T \times f = 0.0367 \text{ J} \times 43 \text{ Hz} = 1.58 \text{ W} \qquad (5)$$

From equation (6), the calculated $P_{T(AV)}$ average total power dissipation is 14.49 W; therefore, external heat sinking is required. The energy and power calculations are a follows:

$$\begin{aligned} P_{T(AV)} &= P_{OFF} \times N + P(QUIES) + P_{ON} \times d \times N \qquad (6) \\ &= 1.58 \text{ W} \times 8 + 0.25 \text{ A} \times 5 \text{ V} + 0.15 \text{ W} \times 0.5 \times 8 = 14.49 \text{ W} \end{aligned}$$

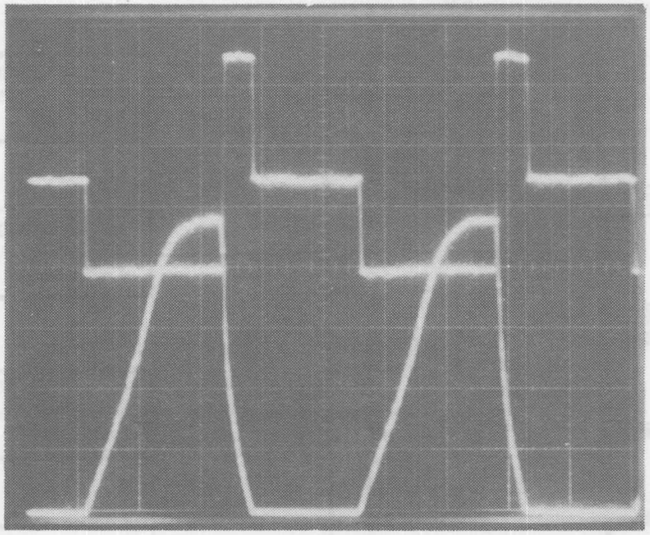
Where:

E_L	Inductive energy stopped in inductor	31.2 mJ
E_R	Energy absorbed by resistance during turnoff transient	9.9 mJ
E_S	Energy from power supply during turnoff transient	15.4 mJ
E_T	Total energy absorbed by each switch during turnoff transient	36.7 mJ
f	Switching frequency	43 Hz
d	Duty cycle	0.5
L_H	Load inductance	250 mH
I_P	Peak output load current	0.5 A
N	Number TPIC2801 switches operating	8
P_{OFF}	Turn-off power dissipation each switch	1.58 W
P_{ON}	On-state power dissipation each switch (see Figure 3)	0.15 W
P(QUIES)	TPIC2801 bias power dissipation	1.25 W
$P_{T(AV)}$	Average total power dissipation TPIC2801	14.49 W
R_L	Resistance of inductor	30 Ω
V_{OK}	Clamp voltage (measured, see Figure 11)	37 V
V_{SS}	Load supply voltage	15.5 V



(a) SIMULTANEOUS TURN-ON/TURN-OFF CIRCUIT

Figure 11. Driving Solenoid Under Worst Case Conditions

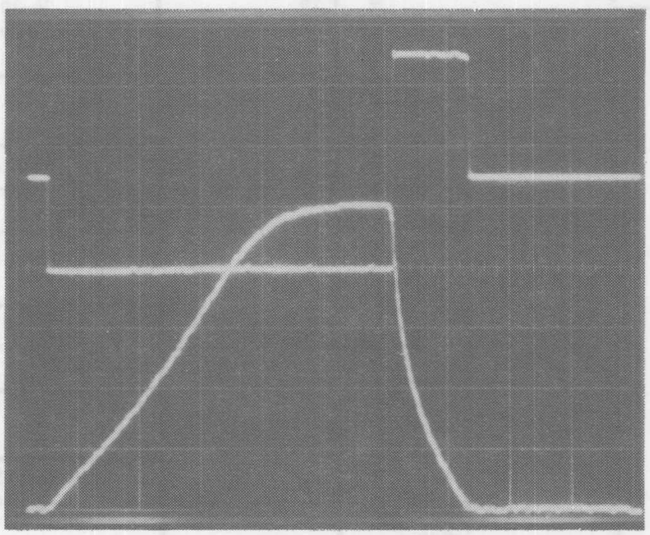


V_{CE} = 10 V/cm

I_C = 0.1 A/cm

Horizontal = 5 ms/cm

(b) V_{CE} AND I_C WAVEFORMS OF TPIC2801 SWITCHING INDUCTIVE EIGHT HIGH INDUCTIVE LOADS



V_{CE} = 10 V/cm

I_C = 0.1 A/cm

Horizontal = 2 ms/cm

(c) EXPANDED VIEW OF V_{CE} AND I_C WAVEFORMS OF TPIC2801 SWITCHING EIGHT HIGH INDUCTIVE LOADS

Figure 11. Driving Solenoid Under Worst Case Conditions (Continued)

self-protected low-side power switches packaged in a 15-pin Single-In-Line Package (SIP). Control of the eight power switches is accomplished by an 8-bit parallel latch, which independently controls each of the eight power switches.

The self-protection capability of the TPIC2801 is illustrated by the design example shown in Figure 7. The TPIC2801 current limiter limits the lamp's initial cold filament in-rush current to approximately 1.5 A while the TPIC2801's output switch overvoltage shutdown circuit permits fault operation of a 100-µs delay period and then turns off the output switch if the switch output voltage still exceeds 1.5 V. It is important to note that these current-limited, 100-µs, soft-start bursts of power not only protect the TPIC2801, but also protect the lamp filament from an otherwise filament degrading, high in-rush current.

The capability to extend the TPIC2801 output switch 1-A load current by parallel switch operation is illustrated by the measurement data shown in Table 1, where data showing up to a 4-A load is switched by eight parallel-connected output switches.

Also, the TPIC2801 is very well suited to switch high energy unclamped inductive loads since each of the eight power switches is equipped with an internal 35-V collector-to-base voltage clamp. To illustrate this capability, Figure 11 shows the test circuit and oscilloscope waveforms of the TPIC2801 switching eight, 36.7-mJ inductive loads (293.6 mJ total energy).

The self-protection features of the TPIC2801 combined with the internal 35-V voltage clamps make the TPIC2801 an extremely reliable device well suited to driving high energy loads requiring up to a few amperes of current in extremely harsh environments such as an automobile.

Acknowledgment

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